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An inverse design method for optimizing design parameters of heat sink modules with encapsulated chip

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ABSTRACT

A three-dimensional inverse design problem in estimating the design variables for heat sink modules with an encapsulated chip is solved in the present study by using the Levenberg–Marquardt Method (LMM) and the general purpose commercial code CFD-ACE+ in an irregular domain. Three different types of heat sinks are examined at a fixed fin array volume to determine the most efficient type of heat sink. Moreover, Aluminum and Copper heat sinks are compared to find the optimum design of the module. Results obtained by using the LMM to solve this 3-D inverse design problem are justified based on the numerical experiments and it is concluded that the double row plate fin type heat sink performs best since it can obtain the lowest temperature distribution on the bottom surface of heat sink module. Moreover, larger heat transfer area of heat sink does not guarantee better thermal performance. Due to higher thermal conductivity of Copper heat sink, it also has better thermal performance than the Aluminum heat sink.

1. Introduction

The central processing unit (CPU)is the heart of computers and must be cooled to satisfy the maximum operating temperature limit by removing the generated heat from the CPU. Nowadays, due to the condition of multifunction, high clock speed, shrinking package size, and higher power dissipations, the heat generation rate of CPUs increased dramatically when comparing with previous CPUs. For this reason, an efficient cooling system to maintain the CPU at a reasonable operating temperature becomes critical to ensure a reliable operation of the CPU.

The heat sink module is the most common heat exchanger for CPUs and has been extensively used in order to provide cooling function for electronic components. The conventional heat sink module utilized the forced convection cooling technique; dissipate heat from CPUs to the ambient air. If there is an appropriate and efficient heat sink design algorithm, it will greatly improve the reliability and prolong the life span of the CPUs. In order to design an effective heat sink, the following design criteria, such as a large heat transfer rate, a low pressure drop, an easier manufacturing process, a simpler structure, a reasonable cost and so on were frequently considered by the previous researchers [1].

Due to the advantageous of simple maintenance process, more reliability, lower manufacturing cost and no environmental concerns for the aluminum air-cooled heat sink, such a cooling module becomes one of the most commonly used devices to cool CPUs. It has been seen by many researchers that a heat sink with good geometrical design will provide better cooling performance and higher efficiency. It implies that the optimization process must be an effective tool for the heat sink design problem.

Many investigations of the optimum design parameters and the selection of heat sink module have been proposed in order to offer a high-performance heat removal characteristic. For instance, in the text book by Kraus and Bar-Cohen [2], they presented fundamental theories for heat transfer and hydrodynamics characteristics of heat sinks. Iyengar and Bar-Cohen [3] utilized the least-energy optimization algorithm to design the plate fin heat sinks in the forced convection problem. Chiang [4] applied the Taguchi method for predicting and optimizing the cooling performance of Parallel Plain Fin (PPF)heat sink module. Chiang et al. [5] used a systematic experimental design algorithm based on the response surface methodology (RSM) to estimate the effects of design parameters of the pin fin heat sink (PFHS)on the thermal performance. Yang and Peng [6] investigated numerically the thermal performances of the heat sink with un-uniform fin width and fin height designs with an impingement cooling. Park and Moon [7] utilized the progressive quadratic response surface model to estimate the optimum fin design variables for a plate fin type heat sink. Zhou et al. [8]

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